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THE HISTORY OF CHEMISTRY IN CHINA

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THE writer recollects in attending his first course in industrial chemistry that the lecturer introduced each subject with the statement, "This substance was first discovered by the Chinese." There were but one or two exceptions to this order of service. More recent studies have caused an expression of a shade of doubt as to the truth of all these claims made in behalf of the Chinese. The people of China did early develop a skill in dyeing, glass-making, manufacture of gunpowder and fire-works, preparation of cements, etc., and this implied a knowledge of some sort of chemistry. The early Chinese knew the distinction between green vitriol and blue vitriol; while Pliny as late as the first century A. D. confounded the two. They had indigo at a very early period and used it in dyeing. They are responsible for many things long before the European world had developed a need for them; but, on the other hand, the tendency has been to consider the hoary annals of Chinese history a convenient dumping ground for disposing of clouded beginnings.

In tracing the early sources of science, it should be noted that there were three distinct centers of almost independent developments—first, India; second, China, and third, the Egypt-Arabia-Europe area which is our own. The Hindus claim responsibility for being the teachers of both China and Europe in cultural matters, but there is doubt as to the validity of their claim, and there seems little ground for believing that in the development of chemical concepts these three areas were very closely related. It is of no small importance to discover that each of these three spheres developed a similar attitude of mind toward natural phenomena and went through the same steps of growth independently.

China likewise began with an age of alchemy; this was followed by the age of the iatro-chemists. These periods in each case were somewhat in advance, chronologically, of our own. An elaborate system of medicine was developed and mercuric chloride was used as an antiseptic in surgery, though there is no ground for believing that the Chinese had any idea of the principle of sepsis. This is but one of the many examples in China where practice far out-

ran theory till theory was left hundreds of years behind. China's ancient bridge-building and canal construction are other examples. The period of the iatro-chemists held sway in China till the close of the nineteenth century, and the modern period has just begun. Two hundred years ago, China and the occident were probably at the same milestone in chemical science. It is just during the last two hundred years that we have forged ahead and the Chinese have stood still.

AGE OF ALCHEMY

The alchemists, as in Europe, began with an interest in the metals. The copper age came to China possibly a little earlier than to the occident, and the working of copper ores and the preparation of its alloys were well known at an early period. Alchemy received form as a distinct art about 1100 B. C. The important metals were five in number—gold, silver, copper, iron, tin. Lead was known but used only as an adulterant of tin so was not dignified by a place among these five. Mercury was likewise known; its common name was and is still *water silver*. These five metals for centuries and centuries were *the* metals. It is of note that in present day Chinese parlance the name for hardware store means when translated *five metals shop*.

With the five metals begins the evolution of the idea "element." The Chinese seem to have been desirous very early to reduce everything to a primary substance, to resolve all compounds into elements. Loa-dze, the Aristotle of China, dates at 700 B. C.; our Aristotle is usually dated 350 B. C. The terms "element," "original substance," etc., are frequently used, and scores of volumes in the literature of older China discourse upon the original primary substance, though with scant experimental support. The five metals were regarded as convertible one into the other; a variation of this idea makes lead a complex which may be changed under proper conditions into any one or all of these. This belief grew from the fact that the galenites of China invariably contain a good sprinkling of all these five metals.

ATOMIC THEORY

The clearest atomic theory makes all compounds and substances reducible to a single substance which is a gas. This gas may recombine with itself and assume various forms and groupings. These are the secondary elements and one philosopher likens them to vortex rings. These now are of two kinds, either positive or negative principles. Combination between a negative and a positive may take place, and all the simple material substances are formed in this way. The theory has a flavor slightly like our present-day

ideas of the constitution of the atom. It is doubtful whether there was any more experimental evidence in the hands of the Chinese to support these ideas than was possessed by Heraclitus with his early fire-air-earth-water theory. It is quite certain, however, that the Chinese did have more actual experience with chemical substances and with what we now call chemical industries than had these sages of ours. This theory was put into its final shape in China about the tenth century.

Gunpowder was one of the substances which the Chinese had early discovered. It was typical of substances whose action was readily explained by this theory; a certain amount of one substance was mixed with a certain amount of another, and positive uniting with negative produced the explosion.

One of the commonly used American chemistry texts makes the statement that in the eighth century the Chinese recognized that air was composed of two gases, an active gas which was termed negative and which would combine with metals, sulphur and charcoal. Moreover, it is stated that they knew that a number of mineral substances evolved this gas on heating, among which was salt peter. The writer has been unable to locate the Chinese sources from which all this information is derived. While the idea of positive and negative principles in chemical combination was a well recognized one applied to all sorts of substances, still the above statement is probably couched in modern phrases which give it more of a chemical flavor than the original Chinese possessed.

No very clear distinction, if any, seems to have been observed between compounds and mixtures, and alloys were looked upon as genuine cases of combination. Much study and experiment was directed to the bronzes. In fact, the composition of the ancient bronzes is one of the interesting topics of chemical study in China to-day. The ancient Chinese seem to have gotten it into their heads that a law of simple ratios was required for the best combinations of copper and tin, and the following comprise the "Six Ratios" from a book dated about 1000 A. D.:

Cu:Sn Ratio	Variety of Bronze
5:1	bell metal
4:1	axes
3:1	spear heads
2:1	swords
3:2	knives
1:1	mirrors

This was probably an *a priori* set of ratios. There may have been some experiment attached, but the theoretical ratios for the manufacture of these different bronzes was not strictly adhered to in practice as recent analyses have shown.

It is of note that zinc and antimony—and China is the present day home of the antimony industry—were identified very late among the metals. Zinc was originally confounded with lead and afterwards became known as *secondary lead* which term it carries in the spoken language of to-day. No mention of antimony is found in the old literature.

The substances derived from the metals—like blue vitriol, the oxides, etc., were all recognized as definite compounds and the Chinese also evolved a “phlogiston theory” proposing a fire element to explain this relationship. This was several centuries before the labors of Becker and Stahl! It was a very obvious method of explaining their observations, since the Chinese possessed almost none of the chemical reagents, acids, etc., which our alchemists used, and heat was the universal agent used in most transformations.

It would be impossible to even touch upon the metallurgy of the ancient Chinese. This had been made a study for centuries and had been reduced to a well-polished art. The actual methods can still be observed in use in China to-day, moreover they are essentially the methods which were in use in Europe before modern industry appeared. A modern metallurgist has suggested that the Chinese discovered the pneumatic method for the manufacture of steel at an early date, and that this accounts for the phosphorus content of the famous Shansi steels.

AGE OF IATRO-CHEMISTRY

Iatro-chemistry reached its high-water mark in the fifteenth and sixteenth centuries. The study of medicine had been assiduously followed by the Chinese down the ages, and the original edition of the *Ben Tsao Gang Mu*, the materia medica used at the present day, was written by old Shen Nung at about 2800 B. C. He is the Chinese “father of medicine” who corresponds to our Hippocrates of about 450 B. C. The original of this materia medica contained mention of one hundred substances. Through later revisions, it has been enlarged to include about six hundred, of which one hundred and thirty-three are inorganic substances. It was put into its present form about 200 A. D.

Many of the inorganic compounds were made directly from the metal, and considerable stress was laid on the purification of the original metals. The methods of amalgamation and cupellation had been both used since ancient times. The important inorganic compounds included blue vitriol, copper carbonate, copperas, the iron salts, tin oxide, white lead, red lead, litharge, and all the common mercury compounds. The methods by which they were made

are similar to those our own alchemists employed. All these methods in remarkable detail are to be found in this *Ben Tsao Gang Mu* which is the handbook in every Chinese drug shop.

White lead is manufactured from little lead plates by a method which is the Old Dutch process in its essential features. China and Holland did have some intercourse in ages back and the suggestion has been made that the Old Dutch process may have come from China.

Practical chemistry in China was held back considerably by the fact that the acids and alkalis, except soda and acetic acid were unknown. Sulphates were prepared by oxidation of the sulphides, and although they did not have sulphuric acid, they were able to bring about the same reactions by using blue vitriol and green vitriol at high temperatures.

ERRORS OF CHINESE SCIENTISTS

Characteristic of the Chinese "scientists" down the ages is that they lacked the inductive method. The philosophers constantly preferred a priori deduction and have reasoned everything by analogy. It seems that they truly had glimpses of the experimental method but deliberately chose the other. A group of natural philosophers arose in the eighth century, whose leader Cheng declares: "You must examine one thing to-day and another thing to-morrow, and when you have accumulated a store of facts your knowledge will burst its shell and come forth into fuller light, connecting all the particulars by general laws." If China had only taken seriously the thoughts of this school instead of deliberately discarding them, we, the occident, might be the student instead of the teacher in the modern school of science.

In addition to this, there is the spirit of inaccuracy which is one of the most real characteristics of Chinese life, which is not so much the cause as it is an attendant feature of China's backwardness in scientific matters. China has a fine system of decimal units, theoretically. But practically, while ten inches always make a foot, a foot may be one of fifty different standards, depending upon what it is that it is desired to measure, cloth, or silk, or timber, etc., and according to the standard used it may signify a length varying from 10 to 16 English inches. Distance along a road is not absolute, but depends on another factor:—is the road easy traveling,—is it through flat, or through mountainous country. A mile up hill is shorter than a mile downhill. There is a very nice practical philosophy behind some of these things, but they all point to an attitude of mind which has tended to retard a desire for accurate measurement and accurate thinking.

CONCLUSION

The above is but a rapid summary of some of the early accomplishments of the Chinese in the field of chemistry. The available Chinese literature has only been superficially touched. It is hoped an interest in more exhaustive studies will be roused.

It is evident that there were early minds at work in China on chemistry, and while difficult to assign dates to each of the important forward steps, it seems clear that previous to the seventeenth century China held her own, and in point of time was possibly a little ahead of Europe. It seems also true that early Chinese investigations were not more entangled with superstition and necromancy than were the European. Chemistry in China stopped growing about three hundred years ago, and admittedly the glory of past achievements fades because the Chinese failed to give their findings to the world.